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(54) **OIL AND GAS RISER SPIDER WITH LOW FREQUENCY ANTENNA APPARATUS AND METHOD**

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Related U.S. Application Data

(63) Continuation-in-part of application No. 13/919,573, filed on Jun. 17, 2013, now abandoned, and a continuation of application No. 12/710,707, filed on Feb. 23, 2010, now Pat. No. 8,464,946, and a continuation of application No. 13/707,121, filed on Dec. 6, 2012, now Pat. No. 8,708,052, and a continuation of application No. 13/300,155, filed on Nov. 18, 2011, now Pat. No. 8,540,030, and a continuation of application No. 12/029,376, filed on Feb. 11, 2008, now Pat. No. 8,074,720.

(51) **Int. Cl.**

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CPC ***E21B 17/006*** (2013.01); ***E21B 19/004*** (2013.01); ***E21B 47/122*** (2013.01); ***E21B 17/01*** (2013.01); ***E21B 19/10*** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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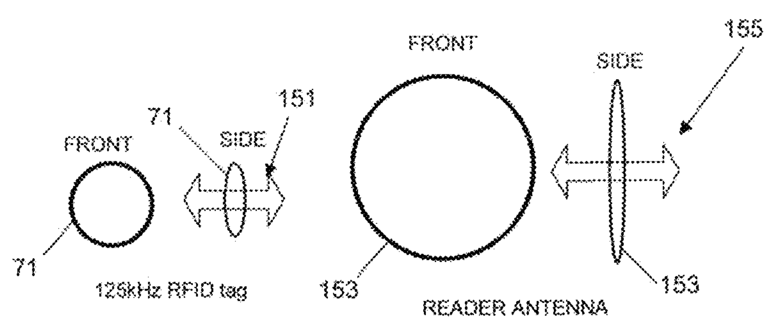
(74) *Attorney, Agent, or Firm* — Bracewell & Giuliani LLP

(57) **ABSTRACT**

Apparatus and methods for tracking a plurality of marine riser assets are provided. Part of a riser lifecycle monitoring system, the apparatus can include an oil and gas riser spider to connect a plurality of riser pipe sections during assembly of a riser pipe string. The riser spider forms an annulus around a first section of the plurality of riser pipe sections and supports the first section of the plurality of riser pipe sections during connection to a second section. The apparatus can also include a reader including an antenna arrangement to read a plurality of radio frequency identification tags, e.g., directional 125 kHz RFD tags, attached to or embedded within an outer surface portion of each of the plurality of riser pipe sections.

22 Claims, 8 Drawing Sheets



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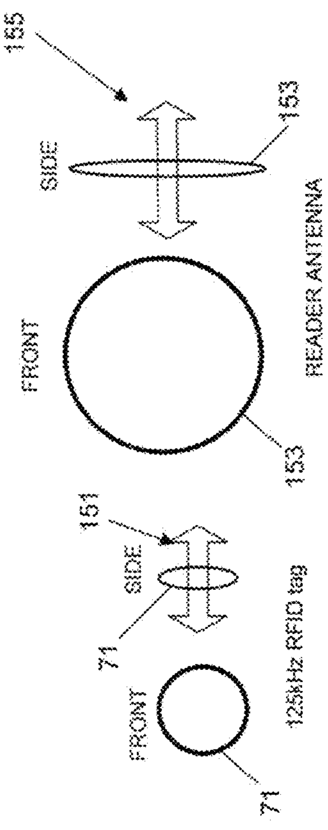

FIG. 1

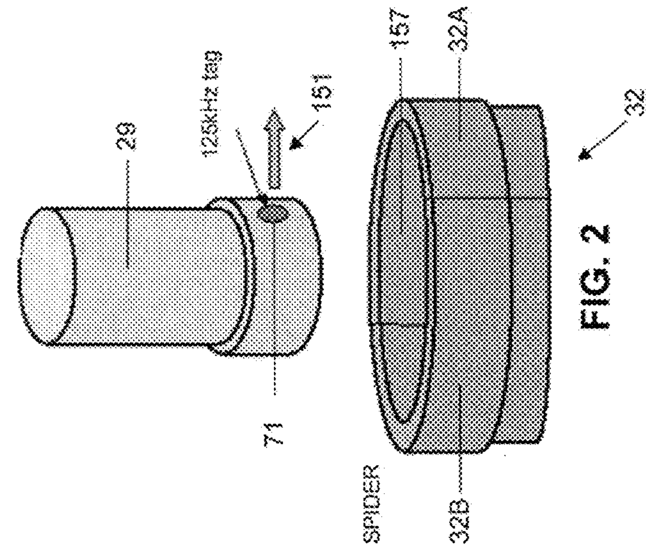

FIG. 2

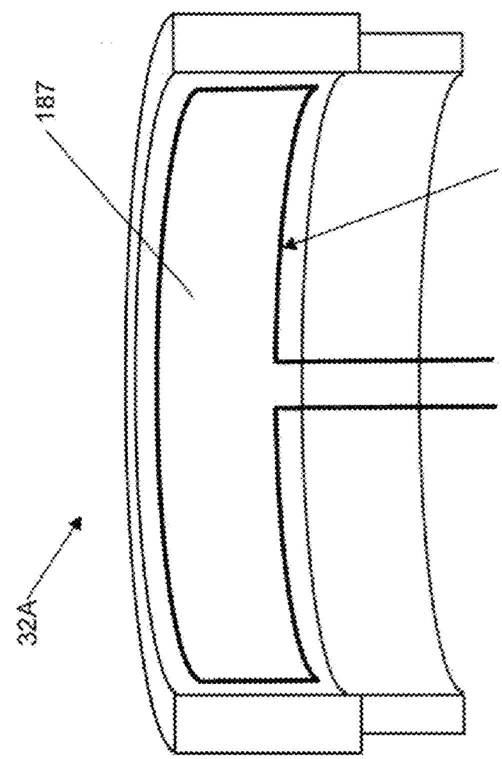

FIG. 3A

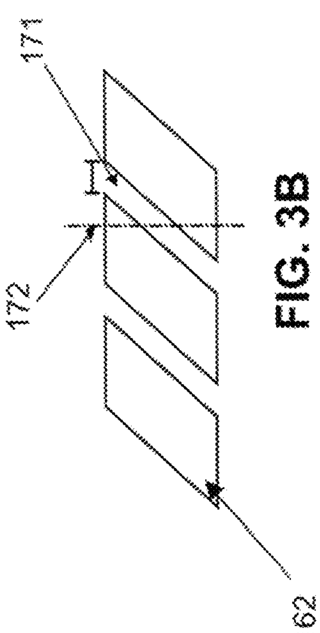

FIG. 3B

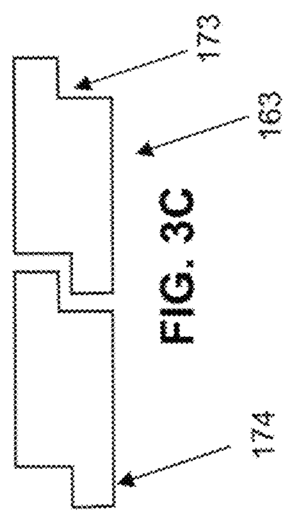

FIG. 3C

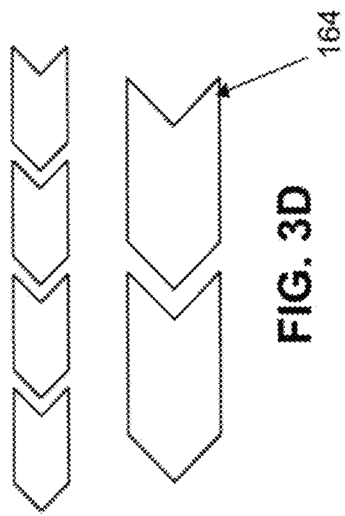

FIG. 3D

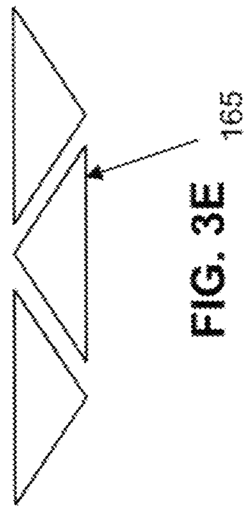

FIG. 3E

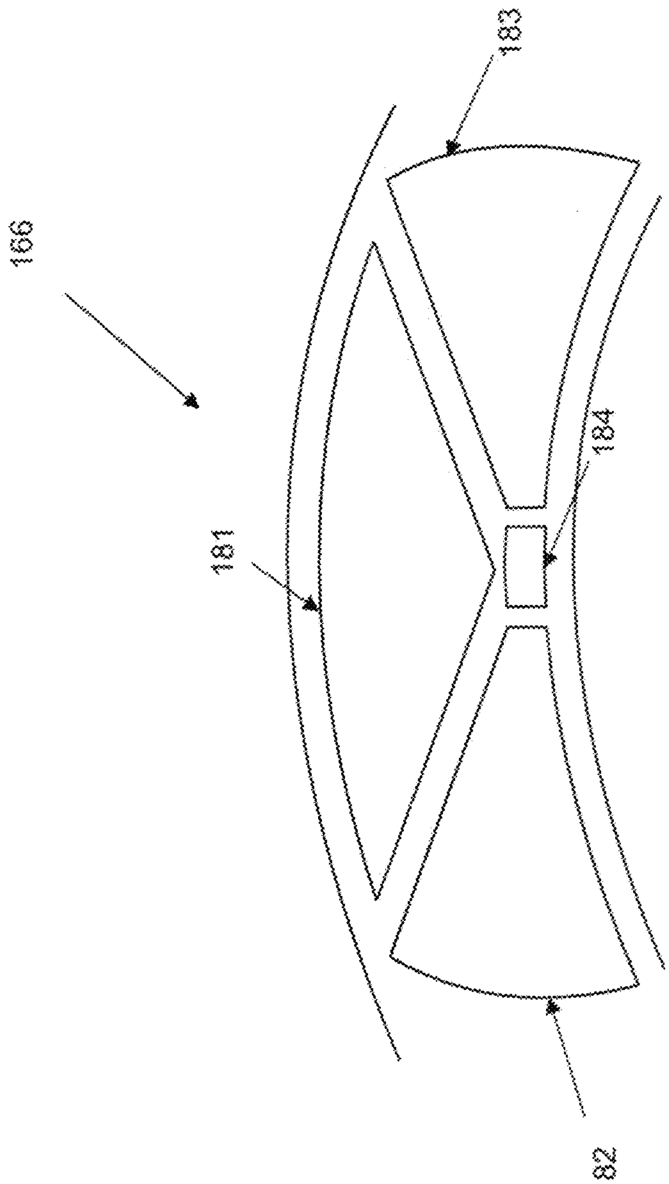

FIG. 3F

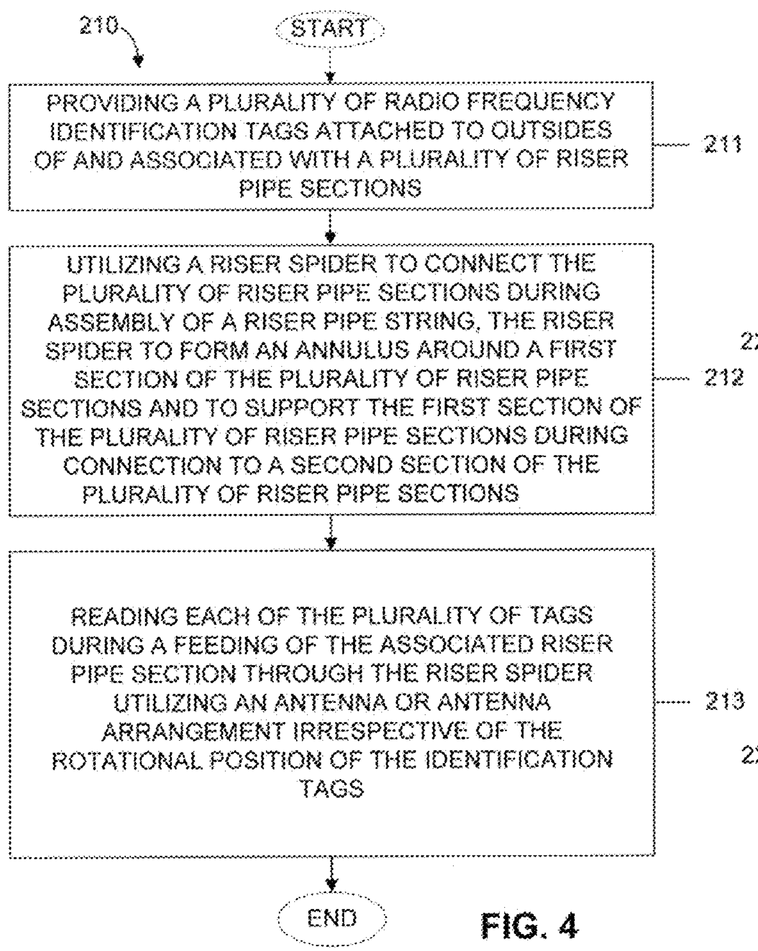
210
START
PROVIDING A PLURALITY OF RADIO FREQUENCY IDENTIFICATION TAGS ATTACHED TO OUTSIDES OF AND ASSOCIATED WITH A PLURALITY OF RISER PIPE SECTIONS
211
UTILIZING A RISER SPIDER TO CONNECT THE PLURALITY OF RISER PIPE SECTIONS DURING ASSEMBLY OF A RISER PIPE STRING, THE RISER SPIDER TO FORM AN ANNULUS AROUND A FIRST SECTION OF THE PLURALITY OF RISER PIPE SECTIONS AND TO SUPPORT THE FIRST SECTION OF THE PLURALITY OF RISER PIPE SECTIONS DURING CONNECTION TO A SECOND SECTION OF THE PLURALITY OF RISER PIPE SECTIONS
212
READING EACH OF THE PLURALITY OF TAGS DURING A FEEDING OF THE ASSOCIATED RISER PIPE SECTION THROUGH THE RISER SPIDER UTILIZING AN ANTENNA OR ANTENNA ARRANGEMENT IRRESPECTIVE OF THE ROTATIONAL POSITION OF THE IDENTIFICATION TAGS
213
END

FIG. 4

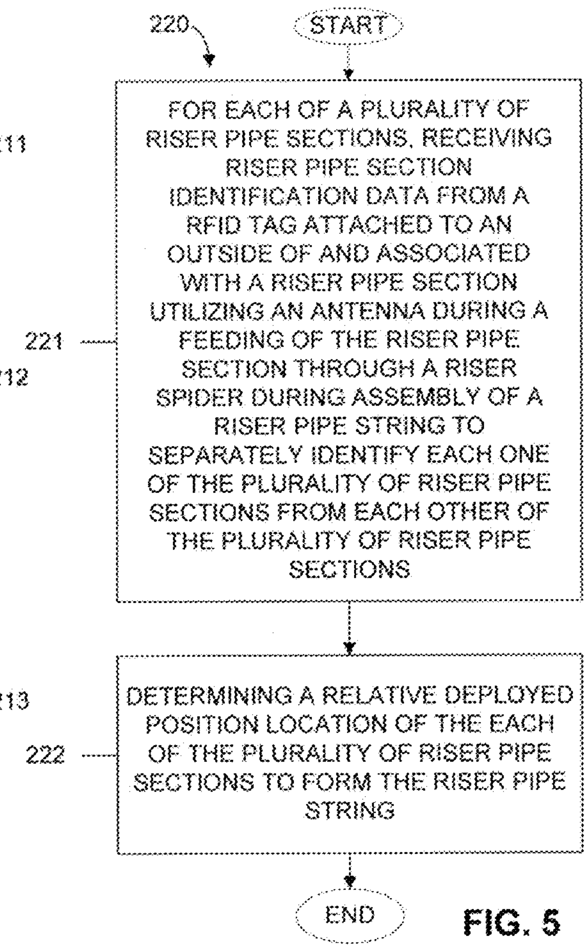
220
START
FOR EACH OF A PLURALITY OF RISER PIPE SECTIONS, RECEIVING RISER PIPE SECTION IDENTIFICATION DATA FROM A RFID TAG ATTACHED TO AN OUTSIDE OF AND ASSOCIATED WITH A RISER PIPE SECTION UTILIZING AN ANTENNA DURING A FEEDING OF THE RISER PIPE SECTION THROUGH A RISER SPIDER DURING ASSEMBLY OF A RISER PIPE STRING TO SEPARATELY IDENTIFY EACH ONE OF THE PLURALITY OF RISER PIPE SECTIONS FROM EACH OTHER OF THE PLURALITY OF RISER PIPE SECTIONS
221
DETERMINING A RELATIVE DEPLOYED POSITION LOCATION OF THE EACH OF THE PLURALITY OF RISER PIPE SECTIONS TO FORM THE RISER PIPE STRING
222
END

FIG. 5

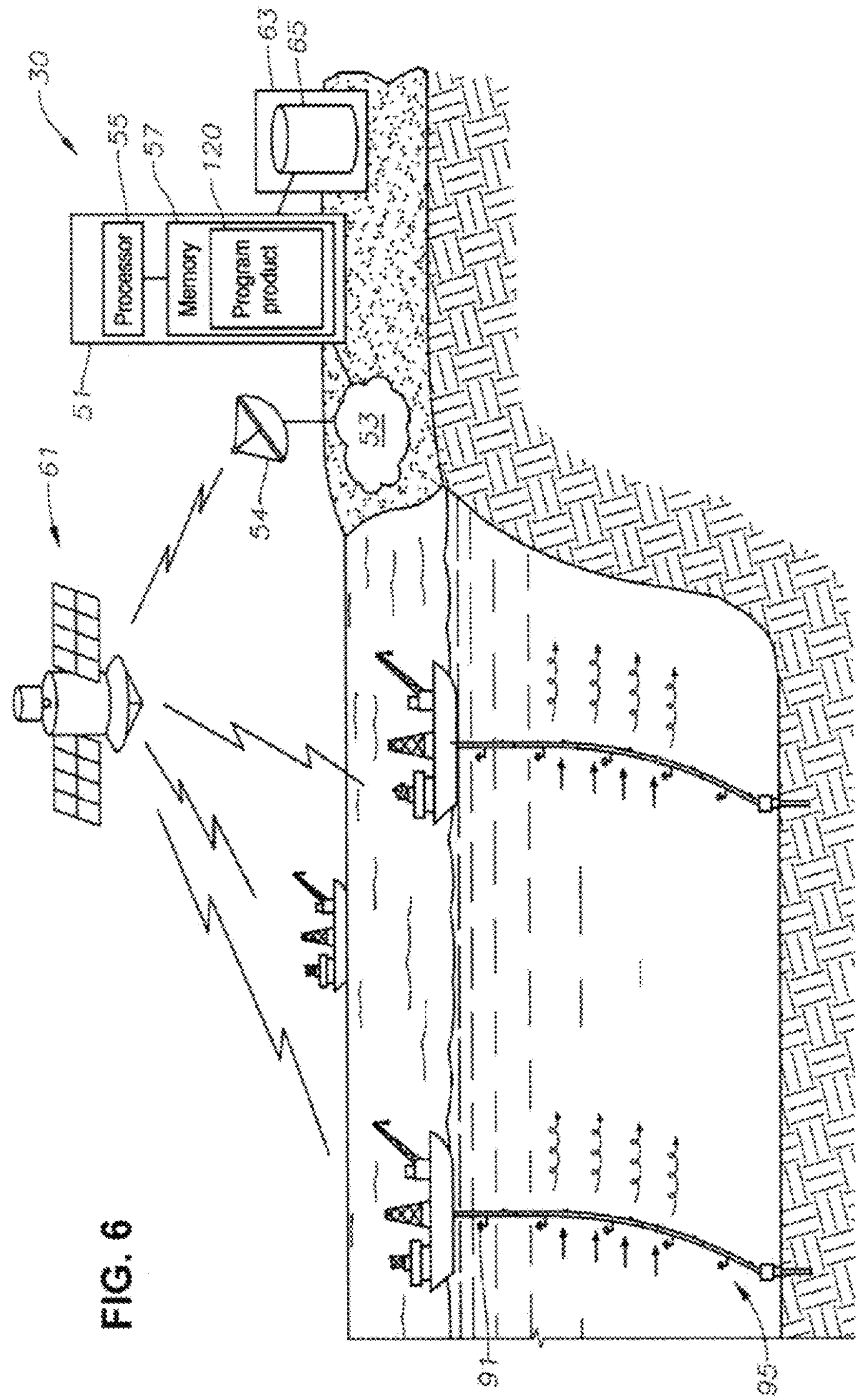
30
55
57
120
63
65
Processor
Memory
Program product
51
61
54
53
91
95

FIG. 6

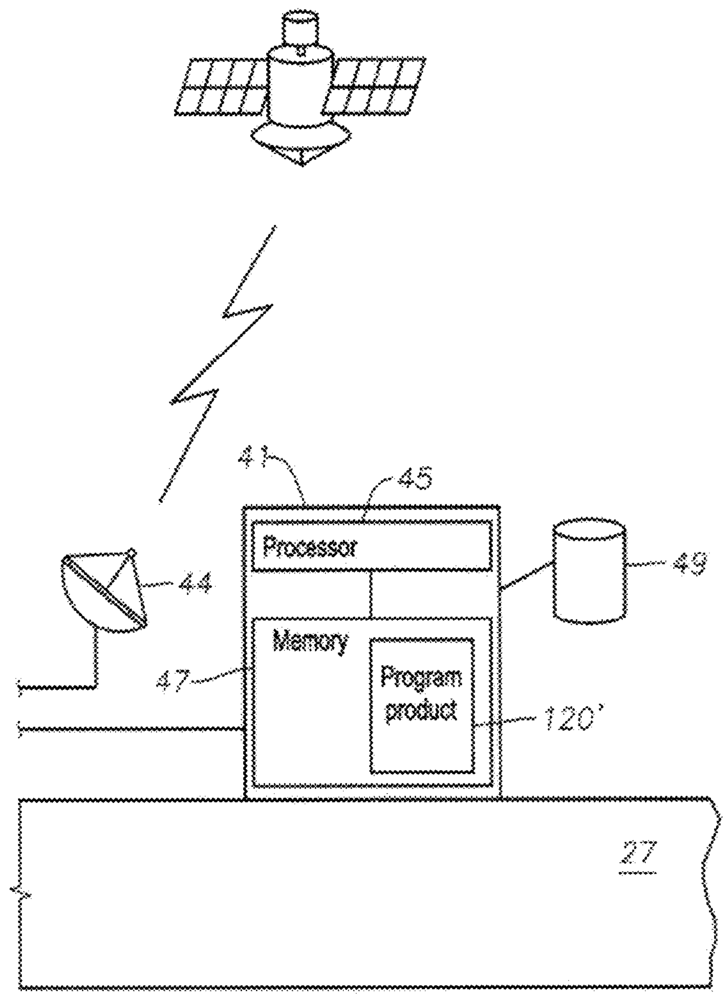

FIG. 7A

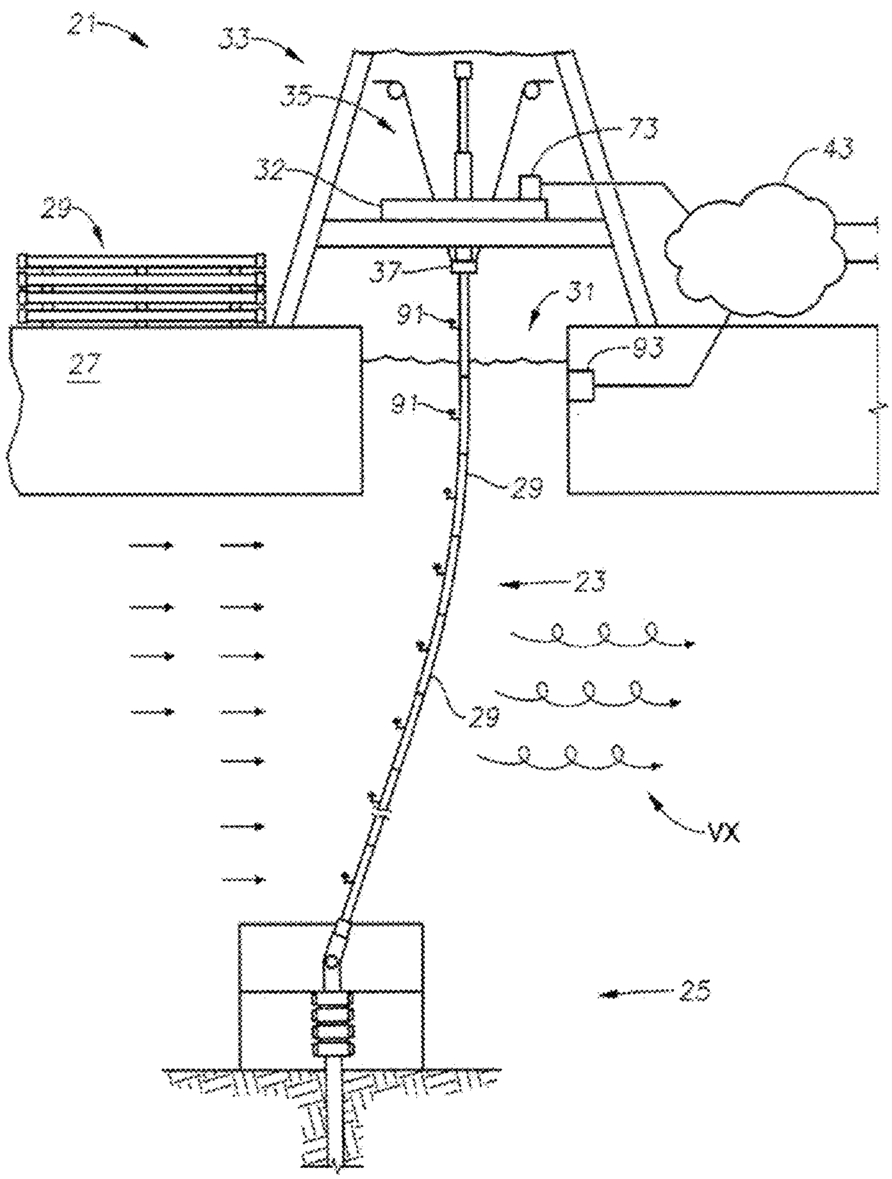

FIG. 7B

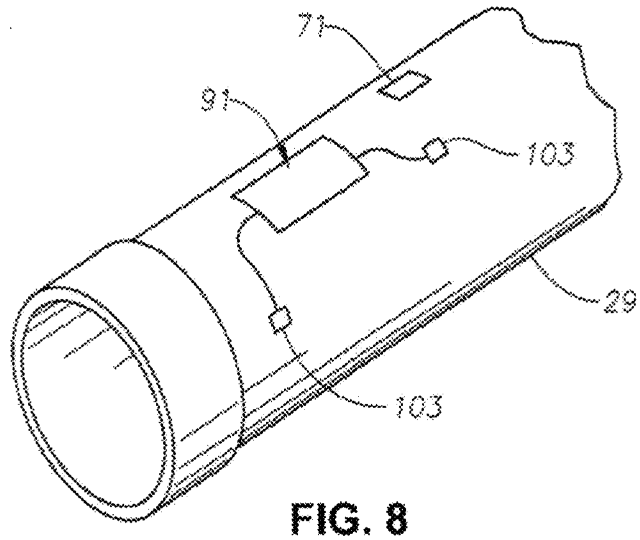

FIG. 8

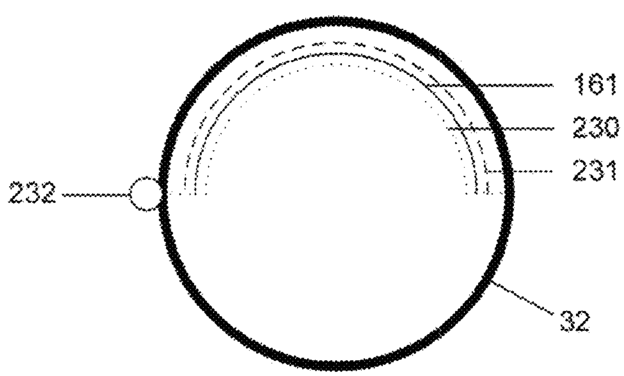

FIG. 9

OIL AND GAS RISER SPIDER WITH LOW FREQUENCY ANTENNA APPARATUS AND METHOD

RELATED APPLICATIONS

This application is a continuation-in-part of and claims priority to and the benefit of U.S. patent application Ser. No. 13/919,573, titled "Oil and Gas Riser Spider with Low-Frequency Antenna Apparatus and Method," which is a continuation of and claims priority to and the benefit of U.S. patent application Ser. No. 12/710,707, titled "Oil and Gas Riser Spider with Low-Frequency Antenna Apparatus and Method"; and U.S. patent application Ser. No. 13/707,121, titled "Riser Lifecycle Management System, Computer Readable Medium and Program Code," which claims priority to and the benefit of U.S. application Ser. No. 13/300,155, titled "Riser Lifecycle Management System, Program Product, and Related Methods," which claims priority to and the benefit U.S. patent application Ser. No. 12/029,376, titled "Riser Lifecycle Management System, Program Product, and Related Methods," filed on Feb. 11, 2008, now U.S. Pat. No. 8,074,720, and is related to co-owned U.S. Pat. No. 7,328,741 B2, titled "System for Sensing Riser Motion" issued on Feb. 12, 2008, each incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the oil and gas industry. More particularly, the present invention relates to an oil and gas spider apparatus with a built-in antenna arrangement and related methods for use in a riser management system that monitors and manages a plurality of marine riser assets having identification tags through utilization of the spider apparatus.

2. Description of Related Art

In the oil and gas industry, a riser is a string of pipe between the sea bottom and ship or rig. Oil and gas riser pipe strings are assembled using a device known as a "spider." The spider feeds and connects each section of riser pipe in the string. Spiders can have different configurations. Some spiders are made of a solid ring that the riser feeds through; some spiders are made of two pieces that close around a riser pipe and then feed the riser pipe through. For each configuration type of spider, the riser pipes are all fed into the spider in the same orientation.

During a typical field installation at sea, marine riser components are individually lifted. from the deck of a vessel, connected to each other at the riser spider, and run down. Riser joints, which comprise the major length of the riser string, are fabricated in lengths ranging from 50' to 90'. During the running procedure, the portion of the riser string that is fully made up is landed on the riser spider. The next riser joint is then picked up and placed just over the spider, immediately above the suspended riser string. The two riser sections are then joined by means of a mechanical connector.

Riser Lifecycle Management Systems (RLMS) have been described, such as in co-owned U.S. Pat. No. 8,074,720. Such riser lifecycle management systems, for example, can provide asset managers a list of all the riser assets allocated to specific vessels and provide a further breakdown of those assets that are currently deployed, are on deck, or are out for maintenance, along with the expected return date; a list of upcoming scheduled maintenance events; an estimate of the amount of operational life being expanded by a particular riser asset; and an estimate of the total amount of operational life used by a particular riser asset, along with the details of the most damaging events (i.e., a certain hurricane event). Such riser lifecycle management systems can include, for example, a central database that can be used by field and maintenance personnel to maintain and communicate critical riser information, and that can enhance both routine maintenance scheduling and identifying a need for an unscheduled maintenance event.

Conventional stationary readers associated with a riser spider can interfere with normal operation of the spider. For example, known designs can require contact of an antenna and tag. Other conventional designs may call for the reader to be positioned too far away from the tag to be read without substantial loss in tag signal or data collisions from other adjacent tags if the tags do not include anti-collision provisions. Currently, directional 125 kHz RFID tags are being embedded in drill pipes and read using a handheld reader in a manual process.

Conventionally, directional 125 kHz RFID tags are being embedded in drill pipes and read using a handheld reader in a manual process.

SUMMARY OF THE INVENTION

In view of the foregoing, Applicants recognize that a manual process for reading riser pipes is error-prone and expensive. Moreover, Applicants recognize the need for apparatuses and related methods for automatically reading riser pipes, without requiring hand-held readers, manual processes, or interference with normal operations. Specifically, Applicants recognize that a low frequency (LF), stationary reader antenna assembly built into a spider would allow riser pipes to be read automatically, as the pipes are loaded. Moreover, Applicants recognize the advantages of an antenna configuration for various spider designs, including both ring and two-piece spiders. Accordingly, embodiments of the present invention advantageously provide an oil and gas spider apparatus with a built-in antenna assembly and related methods. Various embodiments can, for example, enhance a riser management system that monitors and manages a plurality of riser assets, e.g., marine riser assets such as, for example, riser pipes, drilling pipes, or other tubulars capable of fitting through the spider apparatus.

Various embodiments of the present invention include, for example, an apparatus. The apparatus can include a riser spider to connect a plurality of riser pipe sections during assembly of a riser pipe string. The riser spider can be positioned to form an annulus around a first section of the plurality of riser pipe sections and to support the first section of the plurality of riser pipe sections during connection to a second section of the plurality of riser pipe sections. The apparatus can include an antenna to read a plurality of radio frequency identification tags attached to or embedded within outer surface portions of the plurality of riser pipe sections. The antenna can be a single antenna or part of an antenna assembly. According to a configuration, the antenna includes an oblong loop attached to and substantially spanning about half of an internal surface of the riser spider so that the antenna follows the contour of the riser spider. In this configuration, the riser normally carries at least two identification tags (e.g., RFID tags) radially separated from each other by at least approximately 90°. According to another configuration, a second similar hemispherical extending loop is on a second section of a split section riser spider.

According to another configuration, the antenna includes an oblong loop substantially spanning the entire inner circumference of a portion of the riser spider. According to yet another configuration, a plurality of loop antennas are positioned along an inner circumference of either a single-piece spider or a split section riser spider to form an antenna arrangement. According to further configurations, the antenna design can be of various geometric shapes configured to provide mutual coverage along the longitudinal axis of the riser spider so that a marine tabular having a single identification tag connected to or embedded within it surface and passing through the riser spider will pass along one of the antenna and be read by an associated reader. That is, the antenna arrangement configuration can provide 360° coverage, allowing the tubular to pass through with its identification tag at any radial position (orientation) and still be read with a high degree of confidence.

Various embodiments of the present invention can include, for example, a method of tracking marine riser pipe sections. The method can include, for example, providing a plurality of radio frequency identification tags attached to outsides of and associated with a plurality of riser pipe sections. The method can include, for example, utilizing a riser spider to connect the plurality of riser pipe sections during assembly of a riser pipe string or connecting drill pipe to form a drilling string. The riser spider can form an annulus around a first section of the plurality of riser pipe sections and support the first section of the plurality of riser pipe sections during connection to a second section of the plurality of riser pipe sections. The method can include, for example, reading each of the plurality of, e.g., radio frequency identification tags during a feeding of the associated riser pipe section through the riser spider utilizing an antenna or antenna arrangement described above. The antenna or antenna arrangement can be such that the plurality of identification tags are read regardless of their radial position with respect to the riser spider when being operationally deployed.

Various embodiments of the present invention can further include, for example, a method of tracking a plurality of riser pipe sections. The method can include, for example, for each of a plurality of riser pipe sections, receiving riser pipe section identification data from a radio frequency identification tag attached to or embedded within an outside surface of and associated with a riser pipe section utilizing a single antenna or antenna assembly during a feeding of the riser pipe section through a riser spider during assembly of a riser pipe string to separately identify each one of the plurality of riser pipe sections from each other of the plurality of riser pipe sections. The antenna or antenna arrangement can be such that the plurality of identification tags are read regardless of their radial position with respect to the riser spider when being operationally deployed. The method can include, for example, determining a relative deployed position location of the each of the plurality of riser pipe sections to form the riser pipe string.

Other prior solutions require hand-held or stationary readers that alter or interfere with normal operation of the riser pipe string. Various embodiments of the invention negate the need for handheld readers and beneficially do not interfere with the normal operation of either the riser spider or deployment of the riser pipe or drilling string. In addition, embodiments of the present invention advantageously provide a solution for various riser spider configurations, including spiders that are made of two pieces that close around a riser pipe.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the features and advantages of the invention, as well as others which will become apparent, may be understood in more detail, a more particular description of the invention briefly summarized above may be had by reference to the embodiments thereof which are illustrated in the appended drawings, which form a part of this specification. It is to be noted, however, that the drawings illustrate only various embodiments of the invention and are therefore not to be considered limiting of the invention's scope as it may include other effective embodiments as well.

FIG. **1** are schematic views of the directional fields of an 125 kHz RFID tag and a reader antenna according to an embodiment of the present invention;

FIG. **2** is a perspective view of a riser and spider setup according to an embodiment of the present invention;

FIG. **3**A is a perspective view of antenna placement according to an embodiment of the present invention;

FIGS. **3**B-**3**F are schematic views of antenna loops having different geometric shapes that provide overlapping coverage between adjacent antenna loops for enhanced read reliability according to an embodiment of the present invention;

FIG. **4** is a schematic block diagram of method of tracking marine riser pipe sections according to an embodiment of the present invention;

FIG. **5** is a schematic block diagram of method of tracking a plurality of marine riser pipe sections according to an embodiment of the present invention;

FIG. **6** is an environmental view of a system for monitoring and managing a plurality of marine riser assets according to an embodiment of the present invention;

FIGS. **7**A-**7**B are environmental views of a portion of the system for monitoring and managing a plurality of marine riser assets according to an embodiment of the present invention;

FIG. **8** is a perspective view of a riser joint carrying communication and identification hardware according to an embodiment of the present invention; and

FIG. **9** is top view of a schematic block diagram of an apparatus according to an embodiment of the present invention.

DETAILED DESCRIPTION

The present invention will now be described more fully hereinafter with reference to the accompanying drawings, which illustrate embodiments of the invention. This invention may, however, be embodied in many different forms and should not be construed as limited to the illustrated embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

Applicants recognize that a manual process for reading riser pipes is error-prone and expensive. Moreover, Applicants recognize the need for apparatuses and related methods for automatically reading riser pipes, without requiring hand-held readers, manual processes, or interference with normal operations. Specifically, Applicants recognize that a low frequency (LF), stationary reader antenna built into a riser spider would allow riser pipes to be read automatically, as the pipes are fed through the riser spider. Moreover, Applicants recognize the advantages of an antenna for various spider designs, including both ring and two-piece spiders. Accordingly, embodiments of the present invention advantageously provide an oil and gas spider apparatus with a built-in antenna and related methods. One or more embodiments can, for example, enhance a riser management system that monitors and manages a plurality of riser assets, e.g., marine riser assets, drill pipe assets, etc.

One or more embodiments of the present invention include, for example, RFID tags, e.g., 125 kHz RFID tags. As illustrated in FIG. **1**, exemplary 125 kHz RFID tags **71** can be directional and can only he read on one side, defining a read field **151**. As further illustrated in FIG. **1**, a reader antenna **153** face the 125 kHz RFID tags **71** so that its read field **155** is directed toward the antenna **153**. Accordingly, such embodiment or embodiments can include one or more directional RFID tags **71**, as illustrated in FIG. **2**, being positioned on a deployable tubular, e.g., a riser pipe **29**, so that the tag's read field **151** is directed outward. Applicants recognize that otherwise the read field **151** will be directed inward toward the pipe **29** and away from any reader, including, for example, an antenna arrangement built into a spider **32**. A spider **32**, which feeds and connects each section of riser pipe in the string, surrounds or envelopes each riser pipe as it is added to the string so that an inner surface **157** of the spider **32** faces the a directional RFID tag **71** positioned on a riser pipe **29** and directed outward. As further illustrated in FIG. **2**, some spiders **32** are made of two pieces **32**A, **32**B that close around a riser pipe **29** and then feeds the riser pipe through. Note, although described primarily with respect to riser pipe **29**, one of ordinary skill in the art would recognize that the riser spider **32** can also pass other tubulars such as, for example, drill pipe (not shown but represented by riser pipe **29**), which typically has a diameter being smaller than that of riser pipe **29**. As such, if configured with compatible identification tags as would be understood by those of ordinary skill in the art, the riser spider can be used to read and track those tubulars as well.

As illustrated in FIGS. **3**A-**3**F, various embodiments of the present invention can include, for example, placement of an antenna arrangement comprising one or more antenna **161**, **162**, **163**, **164**, **165**, and/or **166**, on or embedded within an inner surface **157** of a spider **32**, or a portion of spider **32**A and/or **32**B.

As shown in FIG. **3**A, an antenna embodiment or arrangement can include, for example, an oblong loop **161** that follows the contour of the spider **32**, or a portion of spider **32**A, such as, for example, an oblong loop **161** attached to and substantially spanning about half of an inner surface **157** of a riser spider **32**, or about 180 degrees of the ring defined by the spider. As illustrated in FIG. **2**, one piece **32**A of a two-piece spider **32** can include an antenna embodiment or arrangement having an oblong loop **161** that follows the contour of the riser spider to thereby provide maximum readability. In various other configurations, the oblong loop **161** need not provide 180° coverage, however, one would expect less confidence that every tag **71** passing through would be read. As such, more than one tag **71** can be utilized and/or the user can ensure that the tubular passing through the riser spider **32** is in the rotational position needed for the tag **71** to pass within the read field **155** of the reader antenna **153**.

In a typical arrangement, the distance between antenna need to be such that the antennas do not couple as would be understood by one of ordinary skill in the art. However, in order to provide 360° of coverage with 100% reliability when using multiple antenna, the antenna design requires the absence of a vertical line separation between antenna loops. Such a separation or gap could result in a missed reading of a tag **71** attached to its associated tubular (e.g., riser, drilling pipe) as it travels through the spider **32**. As such, a desirable antenna design would include no vertical gap between antenna loops.

FIGS. **3**B-**3**F illustrate antenna designs can be of various geometric shapes configured to provide mutual coverage along the longitudinal axis of the riser spider **32** so that a tubular (e.g., riser pipe **39**) having a single identification tag **71** (or additional tags if desired) connected to or embedded within the surface of the tubular and passing through the riser spider will pass along one of the antenna and be read by an associated reader via the reader antenna **153**. That is, the antenna arrangement configuration can provide 360° coverage, allowing the tubular to pass through with its identification tag **71** at any radial position (orientation) and still be read with a high degree of confidence.

FIG. **3**B, for example, illustrates an antenna arrangement having a plurality of parallelogram-shaped antenna **162** oriented so that the gap **171** does not provide a vertical pathway which a tag **71** may pass without being read. Dashed line **172** represents a vertical line illustrating that this particular antenna arrangement does not have any vertical pathways resulting from the gap **171**. In this particular example, the tag will have to pass through the field **155** of at least one and possibly two of the antennae **162** in the arrangement. Note, the distance between antenna forming the gap **171** can be optimized during tuning at installation.

FIG. **3**C illustrates an antenna **163** design having a more rectangular design but with an overhang **173** and foot **174** in order to overlap with adjacent antenna **163**. FIG. **3**D illustrates an antenna **164** design having the shape substantially in the form of the chevron to allow overlapping positioning with adjacent antenna **164**. FIG. **3**E illustrates an antenna **165** design having a triangular shape and having an alternating apex-up, apex-down in order to overlap with adjacent antenna **165**.

FIG. **3**F provides an example of an antenna design **166** that can have multiple antenna loops **181**-**183** configured to cover one spider half **32**A. The upper loop **181** can be in the form of a triangle. The lateral loops **182**, **183**, can be either triangular or frustoconical. Other combinations, however, are within the scope of the invention embodiments. Due to being on a spider half, a tag **71** could be missed in the space between the two spider halves **32**A, **32**B, due to a vertical gap between adjacent lateral loops **182**, **183** for the respective spider halves **32**A, **32**B. To account for this, two or more tags **71** could be installed on the riser pipe **29** or other tubular, separated by at least the width of the gap to ensure read reliability. Additionally, if the antenna design **166** is used on only one of the spider halves **32**A, **32**B, as with either of the other antenna designs **161**-**165**, two or more tags **71** with at least two of them spaced greater than 90° but less than 270° apart, can be installed to ensure read reliability.

FIG. **3**F also illustrates an example of an antenna tuning board **184** used in both this antenna design **166** and in the previously described antenna designs **161**-**165**. The antenna designs **161**-**166** will typically include one tuning board per antenna or one tuning board per two antennas, although other configurations are within the scope of the present invention.

Note, in the two-section riser spider **32** configuration, a vertical line separation can occur along the separation points, resulting in a reduction of reliability that a tubular having a single identification tag **71** will be read to about 96% when the rotational orientation is substantially random. Alternatively, according to one or more embodiments, portions of antenna loops can be connected across the splits between section **32**A, **32**B, through use of antenna bridges as would be understood by one of ordinary skill in the art.

Embodiments of the present invention also include, for example, an apparatus. The apparatus can include, for example, a riser spider **32** to connect a plurality of tubular sections, e.g., riser pipe sections **29**, during assembly of, e.g., a riser pipe string. The riser spider **32** can form an annulus around a first section of the plurality of riser pipe sections and support the first section of the plurality of riser pipe sections during connection to a second section of the plurality of riser pipe sections. The apparatus can include, for example, an antenna arrangement including one or more of antenna **161**, **162**, **163**, **164 165**, and/or **166** to read a plurality of radio frequency identification tags **71** attached to, or embedded within, outer surface portions of the plurality of riser pipe sections **29**. The antenna design can include an oblong loop **161** attached to and substantially spanning about half of an internal surface of the riser spider section **32**A so that the antenna follows the contour of the riser spider, and/or a similar antenna design on the other riser spider section **32**B. One or more of the other antenna arrangements using a plurality of antenna designs **162-165** or one or an opposing pair of antenna designs **166** can also or alternatively be used.

The apparatus can also include an adhesive **231** (see, e.g., FIG. **9**) to attach the antenna or antenna loops to the internal surface of the spider and a protectant **230** (see, e.g., FIG. **9**) to protect the antenna from an ocean environment. The protectant **230** can seal the antenna or antennae to the spider inward facing surface or otherwise protect any exposed antenna or antenna component surfaces. An exemplary embodiment can include use of commercially available polyetheretherketone (PEEK) or marginalized epoxy resin for subsea applications. In other embodiments, attachment of the antenna to the spider can be through clamps, wiring, and other approaches as understood by those skilled in the art. The apparatus can also include a low-frequency, substantially stationary, passive reader **73** of radio frequency identification tags **71**. (See, e.g., FIG. 7B,) The reader **73** can be operably connected to the reader's antenna arrangement.

In an example embodiment of an apparatus, the riser spider **32** can include two portions **32**A, **32**B that together close around the first section of the plurality of riser pipe sections **29** to form the annulus, with each portion comprising a semicircumference of the annulus. The riser spider **32** can also include the two portions being connected by a hinge **232** (see, e.g., FIG. **9**).

Placement of the antenna **161**, **162**, **163**, **164**, **165**, and/or **166** on the inner surface **157** of the spider **32** allows the tag **71** on the riser pipe **29** to be read as it moves through the spider **32**, automatically and without manually bringing a reader to the riser pipe **29** or the riser pipe **29** to a reader, for example. In addition, because no direct contact between the riser pipe **29** and the antenna **201** for the reader is necessary, the exemplary embodiments of the present invention beneficially do not interfere with normal operation of the riser pipe string.

Other prior solutions require hand-held or stationary readers, and necessarily alter or interfere with normal operation of the riser pipe string. In addition, embodiments of the present invention advantageously provide a solution for various riser spider configurations, including both uni-piece spiders and spiders that are made of two pieces that close around a riser pipe.

As illustrated in FIG. **4**, embodiments of the present invention include, for example, a method **210** of tracking marine riser pipe sections **29**. The method **210** can include, for example, providing a plurality of radio frequency identification tags **71** attached to outsides of and associated with a plurality of riser pipe sections (**211**). The method **210** can include, for example, utilizing a riser spider **32** to connect the plurality of riser pipe sections **29** during assembly of a riser pipe string (**212**). The riser spider can form an annulus around a first section of the plurality of riser pipe sections and support the first section of the plurality of riser pipe sections during connection to a second section of the plurality of riser pipe sections. The method **210** can include, for example, reading each of the plurality of radio frequency identification tags **71** during a feeding of the associated riser pipe section through the riser spider **32** utilizing an antenna (**213**).

The antenna arrangement can include either of the antenna/antenna designs **161-166**, described previously, attached to or embedded within, and substantially spanning along the entire inner-facing surface of a single-section riser spider or a multi-section spider if each sections include joint double connectors connecting any antenna loops traversing the splits between riser sections **32**A, **32**B; about half of one or both of the inner-facing surface sections of the riser spider **32** defined by the split between riser sections **32**A, **32**B, so that the respective antenna or antennae follow the contour of respective portions of the riser spider **32**.

As illustrated in FIG. **5**, embodiments of the present invention include, for example, a. method **220** of tracking a plurality of riser pipe sections **29**. The method **220** can include, for example, for each of a plurality of riser pipe sections **29**, receiving riser pipe section identification data from a radio frequency identification tag **71** attached to an outside of and associated with a riser pipe section utilizing an antenna during a feeding of the riser pipe section through a riser spider during assembly of a riser pipe string to separately identify each one of the plurality of riser pipe sections from each other of the plurality of riser pipe sections (**221**). The antenna arrangement can include either of the antenna/antenna designs **161-166**, described previously arranged so that the antenna or antennae follow the contour of the inner-facing surface or surfaces of the riser spider. The method **220** can include, for example, determining a relative deployed position location of the each of the plurality of riser pipe sections **29** to form the riser pipe string (**222**).

FIGS. **1-9** illustrate various portions and optional configurations of an exemplary embodiment of a Riser Lifecycle Monitoring System (RLMS) **30** which provides an integrated tool designed to improve the lifecycle performance of a marine riser through the application of remote diagnostics, online asset management, and readily accessible riser asset maintenance history, and to permit remote management of riser assets, with particular emphasis on riser joints. The riser lifecycle management system includes integrated hardware and software/program product components which can be combined in a central database preferably located on shore. This database can store asset information on every riser lifecycle management system equipped riser in the world. It also can permit transfer of a riser asset from one vessel to another while retaining all historic data. The vessel computers, in turn, can retrieve the data from sensors placed, for example, on each riser asset. The riser lifecycle management system beneficially provides for acquisition of riser load history data. Such acquisition can include gathering sensor data, multiplexing that data, and communicating it through the water column up to a vessel, while allowing for an acceptable level of fault tolerance. The data acquired depends on the type of sensor used on the riser asset. Such data provided by embodiments of the system can also allow for scheduled and unscheduled maintenance and for control of an associated riser tensioning system.

More specifically, as illustrated in FIGS. **6**, **7**A, **7**B, and **8**, the riser lifecycle management system **30** includes portions onshore and portions at each of the vessel locations. As illustrated in FIG. **6**, the portion of the riser lifecycle management system **30** located at an onshore or other centralized location or locations can include at least one computer to remotely manage riser assets for a plurality of separate vessel locations defining a riser lifecycle management server **51** positioned in communication with an onshore local area communication network **53**. The riser lifecycle management server **51** can include a processor **55** and memory **57** coupled to the processor **55**. The memory **57** can include, for example, program product **120**. The riser lifecycle management system **30** can also include a data warehouse **63** which can store relevant data on every piece of riser lifecycle management system equipped riser components anywhere in the world. The data warehouse **63** is accessible to the processor **55** of the riser lifecycle management server **51** and can be implemented in hardware, software, or a combination thereof. The data warehouse **63** can include at least one centralized database **65** configured to store asset information for a plurality of riser pipe sections **29**, i.e., riser joints, and other riser assets of interest deployed at a plurality of separate vessel locations. The asset information can include, for example, the part number, serial number, relevant manufacturing records, operational procedures, and all maintenance records (including detailed information on the nature of the maintenance), just to name a few. This information is generally keyed into the riser lifecycle management system **30** at the time of manufacture or maintenance. The database **65** can also retain deployment and load history information, which can be acquired automatically from shipboard computers **41** located on each riser lifecycle management system equipped vessel 27. See also, e.g., FIG. **7**A.

The riser lifecycle management system **30** can also include riser pipe section measurement instrument modules **91** and a subsurface communication medium **95**, described herein.

The riser lifecycle management system **30** can also include, in communication with the onshore communication network **53**, a receiver/transmitter **54** providing, for example, satellite-based communication to a plurality of vessels/drilling/production facilities each having a receiver/transmitter **44**. The riser lifecycle management system **30** can also include, for example, a global communication network **61** providing a communication pathway between the shipboard computers **41** of each respective vessel **27** and the riser lifecycle management server **51** to permit transfer of riser asset information between the shipboard computers **41** and the riser life cycle management server **51**.

As illustrated in FIGS. **7**A and **7**B, the portion of the riser lifecycle management system **30** located at each at each of the vessel **27** locations can include, for example, a shipboard computer **41** in communication with a local shipboard communication network **43**, e.g., LAN, or local area network. The shipboard computer **41** can include a processor **45**, and memory **47** coupled to the processor **45**. The memory **47** can include, for example, program product **120**. At least one database **49** accessible to the processor **45** of a shipboard computer **41** is also provided which can be used to store asset information for each of the plurality of riser joints deployed from the vessel **27**. Such asset information can include riser joint identification data, riser joint deployment and location data, and riser joint load history data. Also in communication with the shipboard communication network **43** is a receiver/transmitter **44** providing, for example, satellite-based communication to onshore facilities.

As illustrated in FIG. **7**B, the riser lifecycle management system **30** can include offshore drilling and/or production system **21**, including a deployed riser pipe or conductor defining a riser string **23** extending between subsea wellhead system **25** and a floating vessel **27**, such as, for example, a dynamically positionable vessel. The riser string **23** includes multiple riser sections or joints **29** connected together, for example, by a bolted flange or other means known to those skilled in the art. The vessel **27** includes a well bay **31** extending through a floor of the vessel **27**, and typically includes a riser spider **32** positioned on an operational platform **33** in a well bay **31** to support the riser string **23** when riser joint connections are being made or broken during running or retrieval of the riser string **23**. Embodiments of the present invention apply to both drilling and production risers. The vessel **27** also includes a tensioning system **35**, located on the operational platform **33**, which provides both lateral load resistance and vertical tension, preferably applied to a slip or tensioning ring **37** attached to the top of the riser string **23**.

According to an embodiment of the present invention, the riser identification and deployment data for each riser joint **29** (or other riser asset of interest) is communicated, for example, to the shipboard computer **41** by means of a tag such as, for example, an RFID chip or tag **71** (see, e.g., FIG. **8**) positioned on each riser joint **29**, and an appropriate reader **73**, for example, mounted on deck or otherwise connected to the vessel **27** at or adjacent the surface of the sea and operably coupled to or otherwise in communication with the shipboard computer **41** through the local shipboard communication network **43**.

Further, the system **30** can also include riser joint measurement instrument modules **91** each positioned to sense a load represented by strain, riser pipe curve, or accelerometer data, etc., imposed on a separate one of the riser joints **29** forming the riser string **23**, a riser joint load data receiver **93** mounted or otherwise connected to the vessel **27** at or adjacent the surface of the sea and operably coupled to the local shipboard communication network **43** to receive load data for each of the deployed riser joints **29** from the riser joint measurement instrument modules **91**, and a subsurface communication medium **95** illustrated as provided via a series of replaceable wireless data telemetry stations providing a communication pathway between each of the joint measurement instrument modules **91** and the riser joint load data receiver **93** through a water column associated with the riser string **23**.

The measurement instrument modules **91** can determine the magnitude of the loads imposed on the riser string **23** to calculate the magnitude of the stress at various locations on the riser joint **29** or other riser asset. Examples can include excessive stresses, deflections, accelerations, and high frequency alternating stresses in a cross flow motion due to, for example, vortex induced vibration caused by vortices VX. There are a number of methods under which the riser stresses can be measured. In one embodiment, the riser pipe strain is read at a sensor **103**, since conversion of strain data to stresses is fairly straightforward and can be done via a relatively simple computer program element. Alternatively, the riser dynamics can be obtained via accelerometers, which may require a more complex set of operations for conversion to material stress from which the operational (e.g., fatigue) life can then be calculated. The load data sent to the riser lifecycle management server **51** can be in either raw data or converted to local stresses by the shipboard computer **41**, or some intermediate form if some processing is accomplished by the instrument modules **91**. According to an embodiment of the present invention, the sensor **103** is carried by a thin clamp-on composite mat (not shown), which can be used to accurately determine the deflection in the riser joint **29**.

Embodiments of the riser lifecycle management system **30** can also include various methods relating to monitoring and managing a plurality of marine riser assets. For example, the shipboard computer **41** can compare ID data with the list of recently recorded tags. If a duplicate asset is reported, it is disregarded. That is, when utilizing automated reading sensors, the same riser asset may be scanned multiple times while being landed on the spider **32** or during the normal course of handling. As such, the preferred handling procedures can include disregarding duplicate records or duplicate reads within a preselected time period.

Embodiments of the apparatuses and associated methods according to the present invention provide several advantages and enhancements, in the context of a riser lifecycle management system **30**. For example, embodiments provide for automatically reading identification tags on riser pipes, without requiring hand-held readers, manual processes, or interference with normal operations. That is, embodiments provide a low frequency (LF), stationary reader antenna built into a riser spider that allows riser pipes to be read automatically, as the pipes are fed through the riser spider.

In conjunction with a riser lifecycle management system **30**, embodiments of the present invention can track marine riser pipe sections to thereby enable the system to notify automatically an operator of both routine and unscheduled maintenance events. A routine maintenance event is one that is scheduled sometime in advance, but may have been aided by load history information in the database. An unscheduled maintenance event is one associated with an unexpected incident. For example, one or more riser joints in a string that has been subjected to a direct hit by a hurricane may reach a preset fatigue life trigger level, requiring an inspection of the riser joint at the very least. In such a scenario, the operator would have a high degree of confidence that the remaining riser assets are suitable for marine deployment, reducing the down time associated with inspection of the entire riser string.

This application is a continuation-in-part of and claims priority to and the benefit of: U.S. patent application Ser. No. 13/919,573, titled "Oil and Gas Riser Spider with Low-Frequency Antenna Apparatus and Method," which is a continuation of and claims priority to and the benefit of U.S. patent application Ser. No. 12/710,707, titled "Oil and Gas Riser Spider with Low-Frequency Antenna Apparatus and Method"; and U.S. patent application Ser. No. 13/707,121, titled. "Riser Lifecycle Management System, Computer Readable Medium and Program Code," which claims priority to and the benefit of U.S. application Ser. No. 13/300,155, titled "Riser Lifecycle Management System, Program Product, and Related Methods," which claims priority to and the benefit U.S. patent application Ser. No. 12/029,376, titled "Riser Lifecycle Management System, Program Product, and Related Methods," filed on Feb. 11, 2008, now U.S. Pat. No. 8,074,720, and is related to co-owned U.S. Pat. No, 7,328,741 B2, titled "System for Sensing Riser Motion" issued on Feb. 12, 2008, each incorporated herein by reference in its entirety.

In the drawings and specification, there have been disclosed a typical preferred embodiment of the invention, and although specific terms are employed, the terms are used in a descriptive sense only and not for purposes of limitation. The invention has been described in considerable detail with specific reference to these illustrated embodiments. It will be apparent, however, that various modifications and changes can be made within the spirit and scope of the invention as described in the foregoing specification.

That claimed is:

1. An offshore drilling apparatus comprising:

a riser spider for supporting a plurality of riser pipe sections during assembly of a riser pipe string, the riser spider forming an annulus around a first riser pipe section of the plurality of riser pipe sections being deployed therethrough and supporting the first riser pipe section during connection to a second riser pipe section of the plurality of sections, each riser pipe section having an identification tag attached to or embedded within an outer-facing surface of the respective riser pipe section;

an antenna arrangement comprising an antenna attached to or embedded within a substantial portion of an inner-facing surface of the riser spider and configured so that the antenna at least substantially follows the contour of the substantial portion of the inner-facing surface of the riser spider; and

a reader operably connected to the antenna arrangement for reading the plurality of radio frequency identification tags attached to the respective outer-facing surfaces of the plurality of riser pipe sections.

2. The apparatus as defined in claim **1**, wherein the antenna arrangement is configured to provide for reading the identification tag of each of the plurality of riser pipe sections being deployed through the riser spider at any rotational orientation of the respective riser pipe section in relation to a rotational orientation of the riser spider with at least approximately a 96% reliability.

3. The apparatus as defined in claim **1**, wherein each of the plurality of riser pipe sections include at least two circumferentially offset identification tags, and wherein the antenna arrangement is configured to provide for reading at least one of the identification tags of each of the plurality of riser pipe sections being deployed through the riser spider at any rotational orientation of the respective riser pipe section in relation to a rotational orientation of the riser spider with 100% reliability.

4. The apparatus as defined in claim **1**, wherein the antenna arrangement includes a plurality of antenna loops arranged circumferentially along the inner-facing surface of the riser spider.

5. The apparatus as defined in claim **4**, wherein the plurality of antenna loops have a minimum gap spacing to prevent undesired coupling and a corresponding interconnecting geometry between adjacent antenna loops resulting in an absence of a vertical line separation along a longitudinal axis of the riser spider between the adjacent antenna loops.

6. The apparatus as defined in claim **1**,

wherein the riser spider comprises two portions that together close around the outer-facing surface of each respective riser pipe section being deployed therethrough; and

wherein the antenna comprises one or more antenna loops that substantially completely span circumferentially along the inner-facing surface of a first of the two portions of the riser spider.

7. The apparatus as defined in claim **6**, wherein the antenna arrangement further comprises:

a second antenna comprising one or more antenna loops that substantially completely span circumferentially along the inner-facing surface of a second of the two portions of the riser spider.

8. The apparatus as defined in claim **1**, wherein the antenna comprises a single antenna loop that substantially completely spans circumferentially approximately 360° along the inner-facing surface of the riser spider.

9. The apparatus as defined in claim **1**, wherein the antenna comprises a plurality of antenna loops that substantially completely span circumferentially approximately 360° along the inner-facing surface of the riser spider.

10. The apparatus as defined in claim **1**, further comprising:

the plurality of riser pipe sections;

wherein the riser spider comprises two portions that together close around the outer-facing surface of each respective riser pipe section being deployed there through;

wherein the antenna arrangement is employed on only the first of the two portions of the riser spider;

wherein the antenna comprises one or more antenna loops that substantially completely span circumferentially along the inner-facing surface of a first of the two portions of the riser spider; and

wherein each of the riser pipe sections carries at least two identification tags spaced circumferentially apart greater than approximately 90° but less than approximately 270° apart to ensure read reliability.

11. An apparatus, comprising:

a riser spider for supporting a plurality of tubulars during assembly of a tubular string, the riser spider forming an annulus around a first tubular of the plurality of tubulars being deployed therethrough and supporting the first tubular during connection to a second tubular of the plurality of tubulars, each tubular having an identification tag attached to or embedded within an outer-facing surface of the respective tubular; and

an antenna arrangement comprising an antenna attached to or embedded within a substantial portion of an inner-facing surface of the riser spider and configured so that the antenna at least substantially follows the contour of the substantial portion of the inner-facing surface of the riser spider.

12. The apparatus as defined in claim **11**, further comprising:

a reader operably connected to the antenna arrangement for reading the plurality of radio frequency identification tags attached to the respective outer-facing surfaces of the plurality of tubulars; and

a computer configured to determine a relative deployed position location of the each of the plurality of tubulars that form the tubular string.

13. The apparatus as defined in claim **11**, wherein the antenna arrangement is configured to provide for reading the identification tag of each of the plurality of tubulars being deployed through the riser spider at any rotational orientation of the respective riser pipe section in relation to a rotational orientation of the riser spider with at least approximately a 96% reliability.

14. The apparatus as defined in claim **11**, wherein each of the plurality of tubulars include at least two circumferentially offset identification tags, and wherein the antenna arrangement is configured to read at least one of the identification tags of each of the plurality of tubulars being deployed through the riser spider at any rotational orientation of the respective riser pipe section in relation to a rotational orientation of the riser spider with 100% reliability.

15. The apparatus as defined in claim **11**, wherein the antenna arrangement includes a plurality of antenna loops arranged circumferentially along the inner-facing surface of the riser spider.

16. The apparatus as defined in claim **15**, wherein the plurality of antenna loops have a minimum gap spacing to prevent undesired coupling and a corresponding interconnecting geometry between adjacent antenna loops resulting in an absence of a vertical line separation along a longitudinal axis of the riser spider between the adjacent antenna loops.

17. The apparatus as defined in claim **11**, wherein the antenna comprises a plurality of antenna loops that substantially completely span circumferentially approximately 360° along the inner-facing surface of the riser spider.

18. The apparatus as defined in claim **11**, further comprising:

the plurality of riser pipe sections;

wherein the riser spider comprises two portions that together close around the outer-facing surface of each respective riser pipe section being deployed there through;

wherein the antenna arrangement is employed on only the first of the two portions of the riser spider;

wherein the antenna comprises one or more antenna loops that substantially completely span circumferentially along the inner-facing surface of a first of the two portions of the riser spider; and

wherein each of the riser pipe sections carries at least two identification tags spaced circumferentially apart greater than approximately 90° but less than approximately 270° apart to enhance read reliability.

19. A method of tracking marine riser pipe sections, the method comprising the steps of:

providing a plurality of radio frequency identification tags attached to or embedded within an outer-facing surface of a plurality of riser pipe sections, with each of the plurality of riser pipe sections carrying one or more of the plurality of radio frequency identification tags;

attaching an antenna arrangement to or embedding the antenna arrangement within a substantial portion of an inner-facing surface of a riser spider, the antenna arrangement comprising an antenna configured so that the antenna at least substantially follows the contour of the substantial portion of the inter-facing surface of the riser spider;

utilizing the riser spider to connect the plurality of riser pipe sections during assembly of a riser pipe string, to include lowering a first riser pipe section of the plurality of riser pipe sections into the riser spider, supporting the first riser pipe section with the riser spider, and connecting a second riser pipe section of the plurality of riser pipe sections to the first riser pipe section, and repeating to make up the riser pipe string; and

reading at least one of the one or more of the plurality of radio frequency identification tags during a feeding of the associated riser pipe section through the riser spider by utilizing the antenna.

20. A method as defined in claim **19**,

wherein the antenna arrangement comprises a plurality of antenna loops arranged circumferentially along the inner-facing surface of the riser spider; and

wherein the plurality of antenna loops have a minimum gap spacing to prevent undesired coupling and a corresponding interconnecting geometry between adjacent antenna loops resulting in an absence of a vertical line separation along a longitudinal axis of the riser spider between the adjacent antenna loops.

21. A method as defined in claim **19**,

wherein each of the plurality of riser pipe sections include at east two circumferentially offset identification tags; and

wherein the antenna arrangement is configured to read at least one of the identification tags of each of the plurality of riser pipe sections being deployed through the riser spider at any rotational orientation of the respective riser pipe section in relation to a rotational orientation of the riser spider with 100% reliability.

22. A method as defined in claim **19**,

wherein the riser spider comprises two portions that together close around the outer-facing surface of each respective riser pipe section being deployed therethrough, adjacent the antenna;

wherein the antenna arrangement is employed on only the first of the two portions of the riser spider;

wherein the antenna arrangement comprises one or more antenna loops that substantially completely span circumferentially along the inner-facing surface of a first of the two portions of the riser spider; and

wherein each of the riser pipe sections carries at least two identification tags spaced circumferentially apart greater than approximately 90° but less than approximately 270° apart to enhance read reliability.

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